DOCUMENT FRAME RECOGNITION SYSTEM AND METHOD

Field of the Invention

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The current invention is generally related to document recognition, and more particularly related to recognizing frames by a two-step process using a black pixel rectangle and a white pixel rectangle.

10 ## BACKGROUND OF THE INVENTION

Prior to optical character recognition (OCR), an OCR unit recognizes frames in document image data that includes frames in certain forms. For example, the OCR unit generally recognizes the frames at their predetermined positions with respect to the

15   document image data. Similarly, a mark recognition unit also relies upon predetermined positional information of the mark which indicates the frames in the document image data. Japanese Laid Patent Publications Hei11-66225 and Hei9-138837 disclose recognition techniques for determining horizontal and vertical ruled lines based upon a comparison of black pixel runs to a predetermined threshold value and extracting an area enclosed by the

20   four lines as a frame.

Most of the frames recognized in OCR are arranged in two dimensional arrays. FIGURE 1 illustrates frames that are arranged in a table format. The frames extend both in the X and Y directions, and at least two of the four sides are touching with those of

25   adjacent frames. FIGURE 2 illustrates frames that are arranged in a ladder format. The frames extend only in the X direction, and one or two sides are touching with those of adjacent frames. FIGURE 3 illustrates frames that are arranged in an independent format. The frames extend only in the X direction, and no sides are touching with those of adjacent frames. The frames as shown in FIGURES 1 and 2 are defined as complex frames while

30   those as shown in FIGURE 3 are defined as simple frames.

In general, complex frames are more readily recognizable by OCR than simple frames. Even though the complex frames are small in size, since the length of ruled lines of each frame is sufficiently longer than the corresponding character size, the above prior art OCR techniques recognize the frames. On the other hand, since simple frames such as

5   check boxes or single-character boxes are generally equal to or smaller than the corresponding character size, it is difficult to recognize these simple frames based upon prior art recognition techniques. In the prior art recognition techniques, the length of continuous black pixels is compared to a predetermined value in order to extract ruled lines. When the predetermined value is lowered in attempt to accommodate smaller

10   frames, the ruled line candidates are erroneously extracted from character regions and the accuracy is undesirably decreased.

Furthermore, the ruled lines used in the above formats are generally thin. When these formats are scanned by a scanner, the ruled lines are sometimes faded. In particular,

15   when the lines that are printed in light color are scanned by a black-and-white scanner, the ruled lines are frequently faded. To compensate the fading, if the scanner is adjusted to read the thin or light ruled lines in the above formats, since input characters tend to be incorrectly scanned, it is useful to set the scanning sensitivity at a high level.

20   For the above described above reasons, it is desirable to provide a frame recognition technique to recognize at a high precision a single letter frame and a check box that is approximately equal to or smaller than the size of corresponding characters. It is also desirable to provide a frame recognition technique to recognize at a high precision a frame with faded frame lines.

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SUMMARY OF THE INVENTION

In order to solve the above and other problems, according to a first aspect of the current invention, a method of recognizing a frame in a document image, including:

30   inputting document image data; extracting a black pixel rectangle that circumscribes continuous black pixels, the black pixel rectangle defining a parent rectangle; determining whether or not the parent rectangle is a frame candidate based upon a predetermined set of

first criteria; extracting a white pixel rectangle that circumscribes continuous white pixels within the parent rectangle of the frame candidate; and further determining whether or not the frame candidate is a frame based upon a predetermined set of second criteria, the second criteria including at least a comparison of a certain aspect between the white pixel

5   rectangle and the black pixel rectangle.

According to a second aspect of the current invention, a computer readable medium storing a computer program for recognizing a frame in a document image, the computer program providing computer instructions to perform the following steps of:

10   inputting document image data; extracting a black pixel rectangle that circumscribes continuous black pixels, the black pixel rectangle defining a parent rectangle; determining whether or not the parent rectangle is a frame candidate based upon a predetermined set of first criteria; extracting a white pixel rectangle that circumscribes continuous white pixels within the parent rectangle of the frame candidate; and further determining whether or not

15   the frame candidate is a frame based upon a predetermined set of second criteria, the second criteria including at least a comparison of a certain aspect between the white pixel rectangle and the black pixel rectangle.

According to a third aspect of the current invention, a system for recognizing a

20   frame in a document image, including: an input unit for inputting document image data; a black pixel rectangle extraction unit connected to the input unit for extracting a black pixel rectangle that circumscribes continuous black pixels, the black pixel rectangle defining a parent rectangle; a first determination unit connected to the black pixel rectangle extraction unit for determining whether or not the parent rectangle is a frame candidate based upon a

25   predetermined set of first criteria; a white pixel rectangle extraction unit connected to the first determination unit for extracting a white pixel rectangle that circumscribes continuous white pixels within the parent rectangle of the frame candidate; and a second determination unit connected to the black pixel rectangle extraction unit and the white pixel rectangle extraction unit for further determining whether or not the frame candidate is a frame based

30   upon a predetermined set of second criteria, the second criteria including at least a comparison of a certain aspect between the white pixel rectangle and the black pixel rectangle.

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These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and described a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 illustrates frames that are arranged in a table format.

FIGURE 2 illustrates frames that are arranged in a ladder format.

FIGURE 3 illustrates frames that are arranged in an independent format.

FIGURE 4 is a block diagram illustrating one preferred embodiment of the frame recognition device according to the current invention.

FIGURE 5 is a flow chart illustrating overall steps involved in a preferred process for recognizing frames according to the current invention.

FIGURE 6 is a flow chart illustrating steps involved in a first preferred process of the second determination process according to the current invention.

FIGURE 7 is a flow chart illustrating steps involved in a second preferred process of the second determination process according to the current invention.

FIGURE 8 is a flow chart illustrating steps involved in a third preferred process of the second determination process according to the current invention.

FIGURE 9 is a flow chart illustrating steps involved in a fourth preferred process of the second determination process according to the current invention.

FIGURE 10 is a flow chart illustrating steps involved in a fifth preferred process of the second determination process according to the current invention.

FIGURE 11 is a flow chart illustrating steps involved in a sixth preferred process of the second determination process according to the current invention.

FIGURE 12 is a block diagram illustrating a second preferred embodiment of the frame recognition device according to the current invention.

FIGURE 13 is a flow chart illustrating steps involved in an overall preferred process of the frame according to the current invention.

FIGURE 14 illustrates exemplary assumed repeated frame areas.

FIGURE 15 illustrates an example in which there is no overlapping black pixel rectangle in a horizontal direction.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring now to the drawings, wherein like reference numerals designate corresponding structures throughout the views, and referring in particular to FIGURE 4, a block diagram illustrates one preferred embodiment of the frame recognition device according to the current invention. The frame recognition device includes an image input unit 100, an image compression unit 101, an image memory unit 102, a black pixel rectangle extraction unit 103, a working memory unit 107, an output unit 108, a control unit 109 and a frame recognition module 110. The frame recognition module 110 further includes a first determination unit 104, a white pixel rectangle extraction unit 105 and a second determination unit 106. The image compression unit 101 is optionally excluded from the frame recognition device. The black pixel rectangle extraction unit 103

determines a rectangle that circumscribes continuous black pixels and extracts the circumscribing rectangle as a black pixel rectangle. Similarly, the white pixel rectangle extraction unit 105 extracts a white pixel rectangle from an inner area of the parent rectangle, and the white pixel rectangle circumscribes continuous white pixels.

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      Still referring to FIGURE 4, the frame recognition module 110 recognizes at a high precision a single letter frame and a check box that is approximately equal to or smaller than the size of corresponding characters based upon the first determination unit 104, the white pixel rectangle extraction unit 105 and the second determination unit 106.

10 For the recognition of other frames, the frame recognition device optionally includes another prior art frame recognition module and outputs the recognition results in combination with those from the frame recognition module 110. In other words, the current invention is optionally practiced by combining the prior art technology. When a prior art technology is combined, since the following rectangle extraction is substantially

15 common with the prior art technology, a common unit is shared. Although the preferred embodiment of the frame recognition device according to the current invention is a stand-alone device, an alternative embodiment includes a front end processing unit such as an optical character recognition (OCR) unit and or a format definition unit such as an optical mark recognition (OMR) unit for storing a marked frame definition.

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      Now referring to FIGURE 5, a flow chart illustrates overall steps involved in a preferred process for recognizing frames according to the current invention. For example, the following steps are performed by the components of the frame recognition device as shown in FIGURE 1. In a step 200, the image input unit 100 inputs document image data

25 generally in a digital format, and the image memory unit 102 stores the document image data. Further in details, the document image data is directly inputted by a document image scanner or a memory storage unit in a personal computer. In the alternative, the document image data is indirectly inputted via a network or from a portable magnetic storage medium. After the document image data is inputted, the image compression unit 101

30 compresses the data by an OR compression depending upon necessity. The OR compression helps reduce the storage space, the processing time for extracting a black pixel rectangle and an undesirable effect of unclear frame lines. The black pixel rectangle

extraction unit 103 extracts a black pixel rectangle from the document image data in the

image memory unit 102 in a step 201. The black pixel rectangle extraction is optionally

limited to a certain predetermined portion of the document image. The area information

for an extracted black pixel rectangle includes coordinates of corners such as an upper left

5   and a lower right, and the area information is stored in the working memory unit 107. As

described above, the document image data is in the original format or in the OR

compressed format.

Still referring to FIGURE 5, after the above process of the black pixel rectangle

10   extraction, the frame recognition module 110 initiates the following steps for the frame

recognition process. In a step 202, information on one black pixel rectangle is retrieved

from the working memory unit 107. Based upon the retrieved information, the first

determination unit 104 determines whether or not the black pixel rectangle is a frame

candidate or a non-frame candidate in a step 203. To make the above first determination,

15   although there are numerous criteria such as the height, width, area, the number of black

pixels of the black pixel rectangle, the extracted rectangle size is simply compared to the

corresponding character size in the step 203. If the extracted rectangle size is

approximately the same as or smaller than that of the corresponding text, the extracted

rectangle is likely to be determined as a check box or a single-character box.

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One exemplary set of criteria for the first determination includes the following

four conditions:

1-1) a height or width is larger than a first predetermined value.

1-2) a height or width is smaller than a second predetermined value.

25   1-3) a ratio of height and width is larger than a third predetermined value.

1-4) a black pixel density is larger than a fourth predetermined value where the

black pixel density is a result of dividing a number of black pixels in a black pixel

rectangle by the area of the black pixel rectangle. The condition 1-1) excludes black pixel

rectangles whose frame size exceeds for the purpose of writing characters inside the

30   rectangles. For example, the first predetermined value is 2 cm. The condition 1-2)

excludes extremely small black pixel rectangles from the candidates such as below 3 mm

in the document image. The condition 1-3) excludes black pixel rectangles that have a

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disproportionately high ratio of height and width. The condition 1-4) excludes black pixel

rectangles that are substantially filled with black pixels. The 1-4) condition cannot be met

unless a single character frame or a check box is darkened. To count a number of black

pixels for determining the black density value, the first determination unit 104 counts a

5   number of black pixels by referring to the document image data in the image memory unit

102. Alternatively, the black pixel rectangle extraction unit 103 counts a number of black

pixels when a black pixel rectangle is extracted and writes the information in association

with the area information in the working memory unit 107. The latter is generally

advantageous for the processing efficiency.

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In the step 203, the first determination unit 104 outputs a determination result

based upon the above four conditions 1-1) through 1-4). When any one of the conditions

1-1) through 1-4) is met, the first determination result becomes NG. The black pixel

rectangle in question becomes no longer a frame candidate, and the preferred process

15   proceeds to a step 210. In the step 210, if the black pixel rectangle in question is not a last

black pixel rectangle to be examined, the preferred process returns to the step 202 for

making a determination on another black pixel rectangle. If the black pixel rectangle is the

last one, the preferred process proceeds to a step 211 for outputting the results and

terminates. On the other hand, when any none of the conditions 1-1) through 1-4) is met,

20   the first determination result becomes OK. The black pixel rectangle in question now

becomes a parent rectangle and a frame candidate in a step 204. In a step 205, the white

pixel rectangle extraction unit 105 extracts a white pixel rectangle from an inner area of the

parent rectangle or corresponding document image data in the image memory unit 102

based upon the area information of the black pixel rectangle. The white pixel rectangle is a

25   circumscribing rectangle for continuous portions of white pixels. The area information of

the white pixel rectangle such as upper left corner coordinates and lower right corner

coordinates is also stored in the working memory unit 107 in the step 205.

Still referring to FIGURE 5, the second determination unit 106 retrieves the area

30   information from the working memory unit 107 for the white pixel rectangle in a step 206

and determines for the second time whether or not the corresponding parent rectangle is a

frame or non-frame based upon a second set of conditions in a step 207. The detailed steps

of the second determination will be described later. When the second determination results

in that the parent rectangle is indeed a frame in a step 207, the second determination result

is set to OK also in the step 207. For example, in the step 208, a flag in the corresponding

area information is now set to indicate that the rectangle is a frame. Alternatively, similar

5   information is stored in a frame information area in the working memory unit 107. On the

other hand, when the second determination results in that the parent rectangle is not a

frame in a step 207, the second determination result is set to NG. If there is any white

pixel rectangle as determined in a step 209, the preferred process proceeds to the step 206.

The second determination unit 106 retrieves the area information from the working

10   memory unit 107 for another white pixel rectangle in the step 206 and determines for the

second time whether or not the corresponding parent rectangle is a frame or non-frame

based upon a second set of conditions in the step 207. On the other hand, if there is not

any white pixel rectangle as determined in a step 209, the preferred process proceeds to the

step 210 to determine whether or not any black pixel rectangle remains unprocessed.

15   When every black pixel is processed, the preferred process proceeds to the step 211 for

outputting the results to an external unit such as a character recognition unit.

Now referring to FIGURE 6, the above step 207 will be described in a flow chart

illustrating steps involved in a first preferred process of the second determination process

20   according to the current invention. In general, the second determination is based upon a

positional relationship between the parent rectangle and the white pixel rectangle that is

extracted from an inner area of the parent rectangle. In a step 300, the center of a parent

rectangle and that of the corresponding white pixel rectangle are each determined. In a

step 301, a difference between the above determined centers is calculated in pixels. The

25   above center difference is compared to a predetermined threshold value th1 whose

exemplary value is 4 in a step 302. If the difference is equal to or below the predetermined

threshold value, the second determination result become OK in a step 303. On the hand, if

the difference is above the predetermined threshold value, the second determination result

becomes NG (no good) in a step 304.

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Still referring to FIGURE 6, the above second determination process is illustrated

by a numerical example. For example, a parent rectangle has the upper left corner

coordinates (Xso, Yso) and the lower right corner coordinates (Xeo, Yeo) where Xso=365, Yso=840; Xeo=400, Yeo=905. Similarly, an extracted white pixel rectangle has the upper left corner coordinates (Xsw, Ysw) and the lower right corner coordinates (Xew, Yew) where Xsw=372, Ysw=850; Xew=392, Yew=898. Based upon the above exemplary

5   numbers, the center of the parent rectangle is at the coordinate (383, 873) while that of the white pixel rectangle is (382, 874). Thus, the difference between these centers is 1 (one) in both the X and Y directions. Since the difference is below the predetermined value of 4 pixels, the condition is met for the parent rectangle to be determined as a frame.

10   Now referring to FIGURE 7, a flow chart illustrates steps involved in a second preferred process of the second determination process according to the current invention. Differences in coordinate between the parent rectangle and the corresponding white pixel rectangle are denoted by Xs, Ys, Xe and Ye and are determined in a step 400. Based upon the above example with respect to FIGURE 6, the pixel value difference Xs is in pixels and

15   between Xso and Xsw or Xs (Xso, Xsw). Similarly, other pixel value differences include Ys (Yso,Ysw); Xe (Xeo, Xew); and Ye (Yeo, Yew). Among the above determined differences Xs, Ys, Xe and Ye, a max value and a minimal value are determined, and the max-min difference between the max value and the minimal value is determined in a step 401.   The max-min difference is compared to a second predetermined threshold value

20   such as 2 in a step 402. If the max-min difference is equal to or below the second predetermined threshold value, the second determination result become OK in a step 403. On the hand, if the difference is above the second predetermined threshold value, the second determination result becomes NG (no good) in a step 404. For example, if the differences Xs, Ys, Xe and Ye each have 7, 10, 8 and 7, the max-min difference is 10 - 7 or

25   3. Assuming the second predetermined threshold value is 5 pixels, since the max-min difference 3 is below the second predetermined threshold value, the parent rectangle is determined as a frame.

           Now referring to FIGURE 8, a flow chart illustrates steps involved in a third

30   preferred process of the second determination process according to the current invention. Differences in coordinate between the parent rectangle and the corresponding white pixel rectangle are denoted by Xs, Ys, Xe and Ye and are determined in a step 500. Based upon

the above example with respect to FIGURE 6, the pixel value difference Xs is in pixels and between Xso and Xsw or Xs (Xso, Xsw). Similarly, other differences include Ys (Yso,Ysw); Xe (Xeo, Xew); and Ye (Yeo, Yew). In a step 501, the difference between each of the above determined differences Xs, Ys, Xe and Ye and a predetermined ruled line

5   thickness such as 9 pixels is determined, and this ruled line difference is also defined as a second difference. Furthermore, each of the second differences is compared to a third predetermined threshold value th3 such as four pixels in a step 502. If any of the second differences is larger than the third predetermined threshold value in the step 502, the result is set to NG in a step 504. On the other hand, all of the second differences are equal to or

10   smaller than the third predetermined threshold value in the step 502, the result is set to OK in a step 503. By using the example given in the first preferred embodiment, the differences are as follows Xs = 7, Ys = 10, Xe = 8, Ye = 7. Since the predetermined ruled line thickness is 9 pixels in the above example with respect to the third preferred embodiment, a maximal value of the second difference is 2. Under the above example, the

15   result gets OK to indicate that the corresponding parent rectangle is a frame.

Referring to FIGURE 9, a flow chart illustrates steps involved in a fourth preferred process of the second determination process according to the current invention. Within a parent rectangle, horizontal or vertical contiguous black pixel runs are extracted,

20   and a histogram is generated for the length of the extracted black pixel runs in a step 600. A parent rectangle is assumed to be internally devoid of black pixels since the filled rectangles are excluded in the first determination. Based upon the above assumption, the median value in the above constructed histogram is considered as the thickness of ruled lines used in the frame in a step 601. Based upon the above example with respect to

25   FIGURE 6, the difference Xs is in pixels and between a parent rectangle Xso and a corresponding white rectangle Xsw or Xs (Xso, Xsw). Similarly, other differences include Ys (Yso,Ysw); Xe (Xeo, Xew); and Ye (Yeo, Yew). First differences or pixel value differences Xs, Ys, Xe and Ye are determined in a step 602. In a step 603, the difference between each of the above determined first differences Xs, Ys, Xe and Ye and a

30   predetermined ruled line thickness is determined, and this ruled line difference is defined as a second difference. Furthermore, each of the second differences is compared to a third predetermined threshold value th3 such as four pixels in a step 604. If any of the second

differences is larger than the third predetermined threshold value in the step 604, the result

is set to NG in a step 606. On the other hand, all of the second differences are equal to or

smaller than the third predetermined threshold value in the step 604, the result is set to OK

in a step 605.

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In summary, the above described first through fourth preferred embodiments of

the second determination process substantially improve in recognizing frames that are

approximately the same size as or smaller than the corresponding text character size. The

fourth preferred embodiment of the second determination process enables to substantially

10   improve the detection of frames of different ruled line thickness. Incidentally, when any of

the ruled lines in the frame is broken in the parent rectangle frame, the parent rectangle and

the corresponding white pixel rectangle undesirably overlap with each other. Based upon

the example used in the first preferred embodiment of the second determination process,

assuming that a left side ruled line is broken in a parent rectangle, the extracted coordinates

15   of the white pixel rectangle are Xsw=365, Ysw = 850, Xew = 392 and Yew = 898.

Consequently, the result of the second determination in the above first through fourth

preferred embodiments would be NG, indicating that a parent rectangle is not a frame.

Now referring to FIGURE 10, a flow chart illustrates steps involved in a fifth

20   preferred process of the second determination process according to the current invention.

In a step 700, the results of the second determination process are obtained as already

described with respect to FIGURES 8 or 9. Based upon the results, if the result is OK in a

step 701, the fifth preferred process terminates by reassigning OK to the final result in a

step 705. On the other hand, if the result is NG in the step 701, the fifth preferred process

25   checks in a step 702 whether or not there is a match among the differences Xs, Ys, Xe and

Ye each of which is a difference in coordinates between the parent rectangle and its

corresponding white pixel rectangle. If there is no match in the step 702, the final result is

assigned NG to indicate that the parent rectangle is not a frame in a step 704. On the other

hand, there is a match in the step 702, it is determined whether or not a corresponding ruled

30   line exists in a step 703. For example, if Xs matches, since the break in the ruled line is

assumed to be on the left sideline in the parent rectangle, it is determined whether or not

the left side ruled line exists in the step 703. One example of the determination on the

existence of a ruled line is to cont a number of black pixels and to compare the counted number of the black pixels to a predetermined threshold value. If the count exceeds the predetermined threshold value, the ruled line is assumed to exist for the considered side of the parent rectangle. Based upon the step 703, if the ruled line exists, the final result is assigned OK in the step 705. On the other hand, if the ruled line does not exist, the final result is assigned NG in the step 704. The fifth preferred process of the second determination process also substantially improves in distinguishing certain Japanese characters that resemble the characteristics of the frame. For example, the black pixel rectangles of Japanese characters such as "コ " or " ㄴ " appear to miss a left sideline or top and right side lines from a black pixel rectangle. The fifth preferred process of the second determination process correctly distinguishes the above otherwise confusing character images from the above described broken sidelines.

Now referring to FIGURE 11, a flow chart illustrates steps involved in a sixth preferred process of the second determination process according to the current invention. The sixth preferred process also substantially improves the correct detection of frames with a broken sideline. In a step 800, the ruled line thickness is speculated as already described in the steps 600 and 601 with respect to FIGURE 9. A horizontal or vertical contiguous black pixel runs are extracted to generate a histogram for the length of the extracted black pixel runs. Based upon the histogram, the median value is considered as the thickness of ruled lines used in a frame. In a step 801, the difference Xs between Xso and Xsw is determined, and the difference is assigned as a standard threshold value Th. In a step 802, it is determined whether or not the standard threshold value Th is equal to or larger than twice the ruled line thickness. If it is determined that the standard threshold value Th is equal to or larger than twice the ruled line thickness in the step 802, the sixth preferred process assigns the final result to be NG which indicates a non-frame for the parent rectangle in a step 807. On the other hand, if it is determined that the standard threshold value Th is smaller than twice the ruled line thickness in the step 802, the sixth preferred process determines the other differences Ys, Xe and Ye and also determines whether or not any one of them is equal to or larger than (the standard threshold value Th + 5) in a step 803. Again, if any one of the differences Ys, Xe and Ye is equal to or larger than (the standard threshold value Th + 5) in a step 803, the final result is assigned NG in a step 807.

On the other hand, any of the differences Ys, Xe and Ye is smaller than (the standard threshold value Th + 5) in the step 803, it is determined whether or not coordinates between the parent rectangle and its white pixel rectangle match in a step 804. If no match is confirmed in the step 804, the final result is assigned OK, indicating that the parent

5   rectangle is a frame in a step 806. When there is a coordinate match in the step 804, it is further determined whether or not a ruled line exists for the matched sideline in a step 805. If a ruled line exists as determined in the step 805, the final result is assigned OK. However, if no ruled line exists in the step 805, the final result is assigned NG in a step 807.

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The above described preferred embodiments of the frame recognition system and process are implemented in a software program for a general computer, and the software implementation is within the spirit of the current invention. Further more, any storage medium for storing the above software program is also within the scope of the current

15   invention, and these storage media include magnetic disks, optical disks, optomagnetic disks and semiconductor memory chips from which the software program is read by a computer possibly via a network.

Now referring to FIGURE 12, a block diagram illustrates a second preferred

20   embodiment of the frame recognition device according to the current invention. Certain components of the second preferred embodiment of the frame recognition device are substantially identical to those of the first preferred embodiment, and these substantially identical components are referred by the same reference numerals as used in FIGURE 4. The second preferred embodiment of the frame recognition device includes an image input

25   unit 100, an image compression unit 101, an image memory unit 102, a black pixel rectangle extraction unit 103, a working memory unit 107, an output unit 108, a control unit 109 and a frame recognition module 110. The frame recognition module 110 further includes a first determination unit 104, a white pixel rectangle extraction unit 105 and a second determination unit 106. The image compression unit 101 is optionally excluded

30   from the frame recognition device.

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Still referring to FIGURE 12, the second preferred embodiment of the frame

recognition device further includes an imaginary continuous frame area generation unit

120, a black pixel rectangle integration unit 121 and a frame recognition process unit 123.

Conceptually speaking, the second preferred embodiment includes the black pixel

5   rectangle integration unit 121 for integrating black pixel rectangles and the frame

recognition process unit 123. However, in actuality, since the frame recognition module

110 may be also used for the frame recognition, the frame recognition process unit 123 is

not separately implemented. When the frame recognition module 110 is implemented for

use in place of the separate frame recognition process unit 123, the cost reduction is

10   realized in manufacturing of the frame recognition device. Also in the software

implementation, the frame recognition module 110 is used for the frame recognition

process, the program size is reduced, and the run-time memory requirement may be

reduced. Contrarily to the above considerations, when a separate frame recognition

process unit 123 is implemented, if different algorithms are used in the separate frame

15   recognition process unit 123, the recognition device as a whole has more flexibility and

smart in recognizing frames. In addition, the second preferred embodiment of the frame

recognition device according to the current invention may be combined with a prior art

frame recognition device by providing an output interface for the output from the prior art

device to the device of the current invention.

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Now referring to FIGURE 13, a flow chart illustrates steps involved in an overall

preferred process of the frame according to the current invention. Since the overall

preferred process is performed by the second preferred embodiment of the frame

recognition device, components of the second preferred embodiments are referred with

25   respect to the steps as illustrated in FIGURE 12. In a step 200, the image input unit 100

inputs document image data in digital format, and the inputted image data is stored in a

step 900. Depending upon necessity, the image compression unit 101 compresses the

image data. The black pixel rectangle extraction unit 103 extracts a black pixel rectangle

from the document image data in the image memory unit 102 in a step 901. The black

30   pixel rectangle extraction is optionally limited to a certain predetermined portion of the

document image. The area information for an extracted black pixel rectangle includes

coordinates of corners such as an upper left and a lower right, and the area information is

stored in the working memory unit 107. After the black pixel rectangle extraction, the
frame recognition module 110 performs the frame recognition in a step 902. The detailed
steps of the frame recognition are described with respect to the steps 202 through 210 with
respect to FIGURE 5.

Still referring to FIGURE 13, steps 903 through 908 reattempt to recognize
frames that have not been recognized as a frame based upon the same information used in
the step 902. One of the reasons for being unrecognized as a frame is a broken sideline in a
parental rectangle. In general, since a frame arrangement has continuity or repetition, it is
relatively simple to speculate a black pixel rectangle as a frame based upon the position of
an already recognized black pixel rectangle. In a step 903, the imaginary continuous frame
area generation unit 120 generates an assumed repeated frame area based upon an already
recognized black pixel rectangle. Although a single frame may exist by itself, frames
generally exist in a group. For example, one row of frames includes separate frames for an
account number, a telephone number, a name and an address. Moreover, the row of frames
is generally in the same size. In particular, in certain documents such as a checklist, frames
are precisely arranged in a matrix. Since most of these checklists are organized in the
horizontal direction, frames are also likely to be arranged in the x direction. Among the
recognized black pixel rectangles that are recognized as frames, black pixel rectangles that
are arranged in the Y direction are integrated in the X direction, and the integrated black
pixel rectangles are expanded to the entire width of the document or to the specified width
so as to generate the assumed repeated frame area.

After the generation of the assumed repeated frame areas, one of the assumed
repeated frame areas is selected in a step 904. In a step 905, the black pixel rectangle
integration unit 121 integrates from the assumed repeated frame area a highly likely black
pixel rectangle that has been considered as a frame candidate but not as a frame. The
frame recognition module 110 performs a predetermined frame recognition process on the
integrated black pixel rectangle in a step 906. The above described enables to recognize
certain frames that are not necessarily recognized due to two broken sidelines by the
process performed by the first preferred embodiment of the frame recognition device.
After one repeated frame area is processed, the preferred process returns to the step 904 for

repeating the steps 905 and 906 as it is determined that a repeated frame area is left in a

step 907. On the other hand, if it is determined that a repeated frame area is not left in a

step 907, the output unit 108 outputs the information on all of the recognized frames in a

step 908, and the preferred process terminates. When a separate frame recognition unit

5   123 is implemented in addition to the frame recognition module, the step 906 is performed

by the frame recognition unit 123. As disclosed in Japanese Patent Laid Publication 11-

66225, if a break is identified in ruled lines in the integrated black pixel rectangle, the

broken ruled lines are patched. If the patched ruled lines form a rectangle, the black pixel

rectangle is recognized as a frame.

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Now referring to FIGURE 14, rectangles 951, 952 and 953 represent exemplary

assumed repeated frame areas. Within the assumed repeated frame areas 951, 952 and 953,

individual black pixel rectangles as referred by S is satisfactorily recognized as a frame

while those rectangles as referred by F is unsatisfactorily recognized as a frame. The

15   reason for extending the assumed repeated frame areas 951, 952 and 953 to the fullest

width is that the failed frames exist outside of the successfully recognized frames as seen in

the assumed repeated frame area 953. Incidentally, in certain formats, the frames are

arranged in a vertical direction. For the processing of these formats, the assumed repeated

frame areas are extended in the vertical direction to integrate the frame candidates. The

20   imaginary continuous frame area generation unit 120 automatically determines the

direction of the integration of the frames and generates the assumed repeated frame areas.

Furthermore, the imaginary continuous frame area generation unit 120 categorizes the

recognized frames based upon size and integrate the frames of the same size to generate an

assumed repeated frame area.

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FIGURE 15 illustrates an example in which there is no overlapping black pixel

rectangle in a horizontal direction. However, these black pixel rectangles are close with

each other in distance in the horizontal direction, and there is little difference in height. In

these case, these black pixel rectangles are integrated when an assumed repeated frame area

30   is generated.

It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and that although changes may be made in detail, especially in matters of shape, size and arrangement of parts, as well as implementation in software, hardware, or a combination of both, the changes are within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.